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ROCKET POWER -- KEY TO SPACE SUPREMACY

~~Address by Maj. Gen. Don R. Ostrander, USAF, Director, Launch Vehicle Programs, National Aeronautics and Space Administration,~~ at the Semi-Annual Meeting of the American Rocket Society, ~~at~~ Los Angeles, ~~California, on~~ May 10, 1960.

Don R. Ostrander May 10, 1960 14 p

I chose the title for my talk today very deliberately. I thought it was appropriate because I, as the one who has the responsibility for producing the launch vehicles for our space program, am probably the man who is more interested than anyone else in the country in increasing the thrust and the weight-carrying capability of our vehicles. And I am speaking to the group upon whom we are going to have to rely to achieve this - the American rocket industry.

The question has been repeatedly asked and heatedly argued in recent months as to whether we are in a space race with Russia. Now, whether we are in an overall space race with Russia is, I guess, a matter of semantics. The word "race" normally connotes two or more contestants running on the same track, taking the same hurdles, and trying to reach the same goal. In this case we don't know what the other track is like, we don't know what the specific goal of the other fellow is, and we don't know how hard he is running. In addition, I think it would be a mistake, even if we knew these things, to try to pattern our program on his in a sort of "me too", "anything you can do, I can do better" approach. I think that we should set our own goals, point towards them with a broad, logical, scientifically sound program, and then run just as hard as we can. In the long run I firmly believe that we will be better off than by simply shooting for spectacular propaganda firsts. If in the process we achieve significant firsts, fine, but it should be as an outgrowth of our own sound program, not as our sole and primary goal.

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Leaving semantics aside, however, I think that we have to face the fact that we are in a competition - whether or not you want to call it a race - just as we are in financial, economic, psychological and ideological competition across the board. Certainly there is no question in my mind that in my area of responsibility, the area of greater rocket weight-lifting capability, we <u>are</u> in a race and I plan to conduct my business accordingly.

Recognizing then and admitting that it is a competition or a race, or whatever you want to call it, let's review where we stand to date.

Since the Soviets placed SPUTNIK I in orbit in October of 1957, the United States has attempted 40 satellite launchings. These efforts succeeded in injecting 18 payloads into earth orbits, 9 of which are still aloft. During this same period we have tried 5 lunar or deep space probes, of which two can be classed as successes.

I think that it is interesting to try to interpret trends from these statistics. The record shows 17 major launchings by the United States in 1958 and 19 in 1959, with a box score of 47% successes in 1958 rising to 58% in 1959. Before we get too exuberant over this achievement, though, I must point out that we are down to 50% in 1960 so far.

What do these statistics mean? Well, I think they point up several things that are significant. First of all, 45 major launches in a little over two years represent a beginning for our space program of a not inconsiderable magnitude. So far our choice of vehicles has been limited to direct descendants of those with which we began our space effort. All to date are improvisations using components developed either under our various missile programs, or for the VANGUARD IGY program. The second point is the importance of repetitious use of a vehicle in increasing its reliability. The marked upswing in reliability in 1959 can be laid, I think, to improvements in design and to the correction of component deficiencies which were made after diagnosis of our failures. The fact that our record in 1960 has slipped from its 1959 level is attributable in part to the small sample involved - we have attempted only 8 launchings in the first four months of this year. In addition, however, the fact that most of the failures this year have occurred in the AGENA which, even with these failures, has the best record for reliability of any American launch vehicle, emphasizes the necessity for caution in predicting high reliability rates for multi-stage vehicles, and the essentiality of a strong, continuing reliability program throughout the life of a vehicle.

We have no accurate way to determine the reliability which the Russians have achieved in their space program so far. We know of six Soviet successes but we do not know, of course, how many of their attempts resulted in failure. I am sure, though, that all of you in this audience can conclude from your own experiences that their rate falls something short of 100%.

It is no secret that the Soviets outmatch us in the department of rocket thrust, and that as a result they have the capability of placing much heavier payloads in space than have we. You can get any number of very lucid rationalizations of how the U. S. came to trail the Soviets in the matter of rocket size. One of these explanations points out that both the Soviet and U. S. boosters are based on ICBM hardware. Each nation sized its rocket engines to place a high yield warhead on an intercontinental target. Our U. S. warhead technology permitted a lighter vehicle requiring lower thrust than that of the Soviets. All of this is true, but regardless of the reason, the facts of life are that the Soviets did have a large booster vehicle in 1957. With the exception of the VANGUARD program, our development of specialized space vehicle hardware did not really get under way until about a year later. When you consider the remorseless facts of rocket development lead times, I think that it is understandable why we have yet to put into service the new, higher thrust launch vehicle hardware which will enable us to match or surpass Soviet payload achievements.

Although we are behind the Soviets in the weight lifting area, it does not follow that we are far in arrears in overall rocket technology - in our knowledge of how to design, develop and use advanced rocket systems. In fact, I am confident that we are not significantly behind the USSR if you consider this field as a whole, and I think that we may well lead them in many areas.

I have discovered that trying to find out where we stand relative to the Soviets in the field of guidance is a pretty futile exercise. I can get as many opinions as there are experts. Several of our vehicles which are now in or nearing operational status have guidance systems which their salesmen claim have an absolute capability of duplicating the feat of LUNIK III in sweeping around the moon's backside. They point out that the test of a guidance system is not whether a particular LUNIK successfully accomplished this maneuver, but its probability of repeating the performance. That may all be well. The fact remains that they did it, and I, for one, am impressed with it. However we stack up with them today in the field of guidance and control, it appears to me that we are certainly going to need some advancements in the state of the art in order to design a system with the precision and dependability required for the manned lunar landing and earth return mission, for example.

From the standpoint of numbers, our 18 satellites placed in orbit compare very favorably with the Soviet 3, or our total of 23 successful major launchings with their 6, for that matter. From the standpoint of total weight of scientific instrumentation launched into earth orbits, the Soviets are ahead of us by several thousand pounds, and we have not even approached their achievement in payload weight on lunar and deep space probes. However, the yardstick by which our space accomplishments should be measured is not solely by payload weight, nor for that matter the total number of successful launchings, but rather the extent and quality of useful scientific information our payloads have returned to us and the distance this new knowledge has carried us toward our goals.

Our knowledge as to the scientific value of the data that the Soviet space program has gathered to date is far from complete. There is, therefore, no real way for us to compare the two programs thus far. However, our own effort has contributed very significant information of great value to our overall program.

Our program of space exploration really has three elements with related goals. The first of these is the Space Sciences program, which seeks to learn new facts about the shape of the earth, its upper atmosphere, the ionosphere, the earth's magnetic field, cosmic rays, the radiation belt, the aurora, solar-terrestrial relationships, astronomy, etc. Each of our satellites and space probes in this program is instrumented and its flight path is planned to add in a specific way to the overall pattern of knowledge we are painstakingly building. Often some of the most important information comes to us quite by accident. An example is the discovery of the belt of high energy particles from the flight of EXPLORER I, our first satellite, which was probably the most important discovery of the International Geophysical Year. Dr. van Allen and his colleagues had instrumented the payload to observe the primary cosmic ray intensity outside the atmosphere. Saturation of their counters provided the clue which led to further exploration and finally to the now generally accepted theories as to the source of this phenomenon. Subsequent flights by EXPLORERS III and IV provided further data on the Van Allen belt, plus a great deal of other highly useful information.

Interestingly enough, several of the space probes which I classed as failures in the tally I gave you a few minutes ago actually returned a significant amount of valuable information on this phenomenon. For example, PIONEERS I, II and III in late 1958 determined the radial extent of the van Allen belt, discovered a second radiation belt around the earth, and in addition measured a significant departure of the earth's magnetic field from the theoretical predictions.

A great many of the experiments undertaken as part of the Space Sciences program are inspired by requirements of other elements of our program. For example, determination of the extent, intensity, and time variations of the radiation belts; measurements of temperatures inside and on the outside surfaces of satellites; and measurements of the energy and frequency of micrometeorite impacts, all are of great importance to the MERCURY and follow-on man-in-space programs.

This, of course, is the second element of our NASA space program. The goal of Project MERCURY is not the propaganda value of a spectacular first. Rather, its goal is to determine the functions that a man can perform in space to pay his way in future space exploration. Man is a complex servo mechanism - a computer endowed with reason - but he is a pretty delicate mechanism compared with electronic devices and imposes environmental demands which compromise design and cost weight. So one of the things we are trying to find out is for which missions he is worth all this complexity and weight. We have made excellent progress with MERCURY so far. If all goes well, an astronaut should make his first sub-orbital flight this year, and orbit the earth in 1961.

The third element of our program relates to the application of the knowledge which we gain to space systems which can be applied to the good of mankind. For example, as you know, we plan to place in orbit under our Project ECHO, large, metallic coated mylar spheres which can be used as passive reflectors to permit microwave communication over vast distances. Also, weather satellites such as TIROS I, which is still returning excellent televised pictures of cloud cover, and its successors, TIROS II and NIMBUS, will, we hope, allow major advances in weather forecasting.

Thus we are, I think, embarked on a scientifically sound, balanced and aggressive program of our own design. We are literally building our fund of knowledge of space from the ground up, guided by definite goals - our own goals. To date we have been less handicapped by the lack of greater payload capability than is popularly supposed, because much of this early exploratory work which forms the foundation of our later efforts can, with proper planning, be accomplished with the rather primitive tools that we have available. I don't mean to imply that we wouldn't be delighted to launch heavier payloads, and in the near future we are going to <u>have</u> to have order of magnitude increased in our ability to carry heavier weights into space. We are going to have to fly more complex flight paths, and we are going to need a higher degree of guidance precision than we have needed so far.

Now, let us examine our program to create this new generation of launch vehicles we need for the task ahead.

The philosophy upon which our launch vehicle program rests is based upon three fundamental precepts:

- first, we are creating a standardized fleet of trucks, if you want to call it that, with a minimum number of different types in the fleet;

- second, closely linked to the first, we propose to attain reliability through repetitive use of the vehicles in our fleet; and

- third, to avoid early obsolescence, we want to insure that each new vehicle we develop incorporates the most advanced technical approaches and growth potential consistent with the reliability we require.

Before discussing the present and planned vehicles in our program, I would like to dwell for a moment on this philosophy and some of its implications.

Speaking of the first two of these precepts - minimum variety and repetitive use of standardized vehicles - our objectives here are, of course, economy and reliability. The costs of developing launch vehicles are already high and they are going up in a geometrical progression with each new, larger, and more advanced vehicle that we add to our fleet. The Nation cannot, and fortunately need not, afford two major vehicles, one NASA, one military, with approximately the same capability. That is why we are conducting cooperative programs with the military on the SCOUT, the AGENA B, and the CENTAUR. That is why, too, that we cancelled VEGA in favor of the Air Force AGENA B. There was nothing inferior about the VEGA vehicle. It was just that the AGENA B was a little ahead, time-wise, and could do the same job, plus the fact that with a cooperative program we would get more total firings and consequently more reliability.

While on the subject of a minimum variety and repetitive use of vehicles, I want to stress that this same philosophy governs the NASA component and technique development program. We explore various technical approaches methodically and, I think, adequately, in our applied research efforts. But we try to settle on one approach which our analysis shows to be best before we go into full scale hardware development. An example is our decision to use liquid hydrogen and liquid oxygen as a propellant-oxidizer combination for chemical upper stages. We made this choice after a lot of careful study and experimentation. We plan to use this combination in nearly all of our chemical upper stages in preference to other competitive combinations. Meanwhile, just to be sure we have not overlooked a break-through, we will continue researching other combinations, but at a lower level of effort and on a highly selective basis.

I think the contribution to reliability of amassing a large number of flights on a given vehicle is obvious. I want to add, though, that we do not subscribe to the "develop in haste and fix at leisure" route to reliability. In our kind of business such an approach is patently unacceptable. These devices have to work the first time they are launched or the entire cost of the flight is wasted. NASA is reliability-conscious to the point where I think some of our project people would be glad if they never heard the word again. We have recently added a staff element, headed by Dr. Landis S. Gephart, to direct the NASA-wide reliability program. Our operating elements, such as the George C. Marshall Space Flight Center in Huntsville, have engineering groups whose sole business is to insure that reliability is considered at every step, from conceptual design, through detail design, selection of materials and components, development test, flight test, production quality control, and launch procedures - the entire spectrum of operations which influences the probability that complex launch vehicles, spacecraft, and all the myriad elements that make up the space mission systems, will function as intended.

On the other hand, we cannot allow our desire for reliability to become such an overriding obsession that we timidly decide on the tried and true - and often obsolescent - approach in planning each new vehicle. That is why we have the third precept I mentioned. The tough job is to have <u>both</u> reliability and long, useful life. NASA is tackling this job by aggressively probing for real break-throughs which promise quantum gains in mission capability. We bet heavily, to win, only after we have solid evidence that we have a winner. An example is the ROVER program which I would like to talk about a little more later on.

Now I would like to discuss, very briefly, the vehicles we now have in our fleet, and the standardized ones we are developing for the future.

As I mentioned earlier, we are still limited to the launch vehicles with which the U. S. began its space program, or their direct descendants. A few have been retired - the JUPITER C which served us so well back in 1958 when we so greatly needed a U. S. satellite in orbit to repair, in some measure, our badly mauled prestige; and the VANGUARD which, in spite of its troubles, more than earned its development cost in the information provided by the three scientific payloads it orbited. In addition, it paid dividends by giving us upper stages for the THOR-ABLE, the THOR-DELTA, and the SCOUT.

Also due to be retired this year is the JUNO II, based on the JUPITER IRBM, and the THOR-ABLE. The THOR-DELTA, which is a THOR-ABLE improved through the addition of coasting flight attitude control and the accurate and flexible TITAN radio guidance system, will be used through 1961 in a 12-vehicle program, but no follow-on procurement is planned.

All of these vehicles are destined to be replaced by two vehicles, the SCOUT and the THOR-AGENA B - the SCOUT because of its relatively low cost, which is about $750,000 per copy including all launching costs, and its high reliability potential; and the THOR-AGENA B because of its combination of greater payload, flexibility of operation, and potential high reliability.

As far as payload capability is concerned, the VANGUARD and JUPITER C could place in a 300 mile orbit about a 25-pound payload. The JUNO II could perform the same mission with a 100-pound payload, the THOR-ABLE 200 pounds, and the DELTA configuration will more than double this performance with about a 480-pound capability for this particular mission. Of their successors, SCOUT can handle a 200-pound payload for a fraction of the cost, and the THOR-AGENA B will be able to put 1,250 pounds in a 300 mile orbit.

The AGENA B stage will also be used by NASA, as well as the Air Force, on top of the ATLAS as a first stage. The ATLAS booster will increase the 300 mile orbit payload capability of the AGENA B to about 5,300 pounds.

Later in 1961 we are scheduled to launch our first CENTAUR. The CENTAUR will be the first vehicle to employ a high energy upper stage, and this liquid hydrogen-liquid oxygen stage is the first to employ a rocket engine developed primarily for space use. The added specific impulse afforded by hydrogen as a fuel gives the CENTAUR half again the payload of the ATLAS-AGENA B in a low orbit, and nearly three times as much payload when used as a lunar probe, which is one of its principal missions in the NASA program. For the first time, in CENTAUR, the U. S. has a launch vehicle able to duplicate the payload capability of the SPUTNIK vehicle.

The CENTAUR is of major interest to the Department of Defense as well as to the NASA. In fact, the CENTAUR performance objectives originally stemmed from the DOD requirements for a 24-hour communications satellite. The importance of the CENTAUR to NASA, however, is much more far-reaching than the capability of the CENTAUR vehicle itself because of its relationship to SATURN. The CENTAUR upper stage will become the top stage for SATURN. In addition, four CENTAUR engines will power the second SATURN stage. In fact, liquid hydrogen begins to look as though it will dominate the launch vehicle upper stage picture both as a fuel for chemical rockets and as a working fluid for nuclear rockets.

The SATURN vehicle is being developed under the management of Wernher von Braun's Marshall Space Flight Center. As most of you know, the SATURN first stage consists of a cluster of eight uprated JUPITER-THOR type engines, with a total thrust of 1,500,000 pounds. On top of it we will use the two hydrogen-oxygen stages I just mentioned. When we get this SATURN C-1 vehicle, which is the initial version of SATURN, our payload capability gets a king-sized boost - to 25,000 pounds in a 300 mile orbit.

One, and possibly two later versions of SATURN are planned. The second model, called C-2, will add another stage using four 200,000 pound thrust LO_2 - LH_2 engines. The third model, if we decide to build it, will be called the C-3 and will have still another stage, using two of these 200,000 pound thrust engines.

We have had a great deal of study and analysis in progress for the past year to try to define the vehicle which will follow the SATURN. The principal mission which we have used as an objective in these planning studies has been that of landing a manned spacecraft on the moon, then returning a 10,000 pound reentry package to the earth. The study has followed two principal approaches. The first was what you might call the brute force attack, known as NOVA.

There have been many references to NOVA, as a vehicle, in the press and elsewhere. NOVA is not a vehicle - it is simply one of a number of vehicle concepts which we have considered for the use of the 1,500,000 pound thrust single chamber F-1 engine now under development for NASA at Rocketdyne. Under this brute force approach, six of these large $1\frac{1}{2}$ million pound thrust engines would be used in the first stage. Four hydrogen-oxygen stages could be piled on top of this big booster to give us the 10,000 pound lunar return package that we need.

This concept is beginning to face increasing competition from vehicle studies with nuclear upper stage rockets. Encouraging results from the initial KIWI-A nuclear rocket reactor test last summer have stimulated our hopes that the large increase in efficiency which we get from using one or more nuclear upper stages, with weights less than one-third that of the NOVA for the same mission capability, can be acquired by the time our program has reached the point where we need something beyond SATURN. Toward that end, the NASA and the AEC are increasing the pace of the ROVER program, as the nuclear rocket program is known, aiming for an orbital flight test of a prototype nuclear rocket in 1965, on top of SATURN as a launch vehicle.

The NASA has developed, during the year and a half of its existence, a long range plan. We have done this in order to set ourselves some long range goals and a tentative timetable for reaching those goals, so that our research and development program could be constructed by a process which more nearly resembled interpolation than extrapolation. This planning effort has given our program, I believe, a clear sense of direction and pace.

As to direction, the major long range goal of the NASA program is manned exploration, first of the moon, then the nearer planets. This goal focuses attention on the vehicle development program, the MERCURY program and follow on manned earth satellite programs, preliminary unmanned explorations of the lunar surface, the variation of the space environment between the earth and the moon, and on all the host of basic and applied research which must provide us with the information we need to realize this goal.

The plan also projects the space sciences and satellite applications programs. As I mentioned before, the Space Sciences program gains direction and emphasis from this objective of ultimate manned lunar and planetary exploration. Our satellite application program will continue to develop improved means of microwave communications and improved means of forecasting weather through meteorological satellites.

To carry out these programs, NASA will launch between 25 and 35 major vehicles and 100 sounding rockets a year over the next three years. Actually, in later years the pace of individual launchings may go down somewhat rather than increase, as we place in service the new, large, complex and exceedingly expensive vehicles such as SATURN and its successors, each of which will have the payload capability of several of its predecessors.

I would like to summarize then by simply saying that I feel we are embarked upon a broad, technically sound and logical program with definite goals in mind - our own goals. We are undoubtedly going to have our share of failures in this program - as you in this audience know so well, they have to be expected in this kind of work - and we will undoubtedly have to adjust the detailed timing and content of the program as we move along and learn more. But we do have a plan, we are getting good support from both the Administration and Congress, and I feel from my short experience with NASA that we have outstandingly competent people at all levels of the organization to supervise the program.

We were awfully late in getting started, but I feel that we are now off and running. This is not a crash program that I am talking about, but it is a vigorous and an aggressive one. My prediction is that in the long run it is going to prove sounder than a hysterical crash program trying to compete for spectacular propaganda firsts.

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